VERMONT
ENVIRONMENTAL CONSERVATION

Otter Creek

Watershed Description

This bacteria TMDL summary applies to a 4.8-mile reach of Otter Creek, a 92-mile long stream located southeast of Lake Champlain (Figure 1). Otter Creek is Vermont's longest stream draining almost half of Rutland County and nearly all of Addison County, before flowing into Lake Champlain in the Town of Ferrisburg (ACRWC, 2009). The creek's headwaters originate to the south in the towns of Mount Tabor, Peru, and Dorset in the heart of the Green Mountain National Forest. Otter Creek's bacteria-impaired segment begins at the confluence with the Middlebury River, which is also impaired for bacteria. The impaired reach flows 4.8 miles downstream to Pulp Mill Bridge on the Middlebury-Weybridge town line. The watershed for the impaired segment (Figure 1) covers 630 square miles, covering half of Rutland county and the southern portion of Addison County. Overall, land use in the impaired watershed is 74% forested, 15% agricultural, 3% developed, and 8% wetland, as shown in Figure 2 (based on 2006 Land Cover Analysis by NOAA-CSC).

Otter Creek is an important natural feature within Rutland and Addison County. The soils along the creek's bank and within its floodplains are ideal for agriculture. Along its course the creek flows through the largest and most biologically diverse swamp complex in New England (Nature, 2011). There are multiple conservation and wildlife management areas along the creek. Cornwall Swamp, which resides within the watershed of the impaired segment, was designated a National Natural Landmark by the U.S. National Park Service in 1974 (VTF&W). Figure 3 provides a more detailed aerial view of Otter Creek in the downstream reaches with sampling stations indicated. The impaired segment of Otter Creek begins upstream of sampling station OTR22 (Figure 3). The sampling stations utilize river miles, distances upstream of the mouth of the river, in their title. For example "OTR22" is situated 22 miles from the mouth of Otter Creek.

Waterbody Facts (VT03-01)

- **Town:** Middlebury
- **Impaired Segment Location:** mouth of Middlebury River to Pulp Mill Bridge
- **Impaired Segment Length:** 4.8 miles
- **Classification:** Class B
- **Impaired Segment Watershed Area:** 630 square miles
- **Planning Basin:** 3-Otter Creek

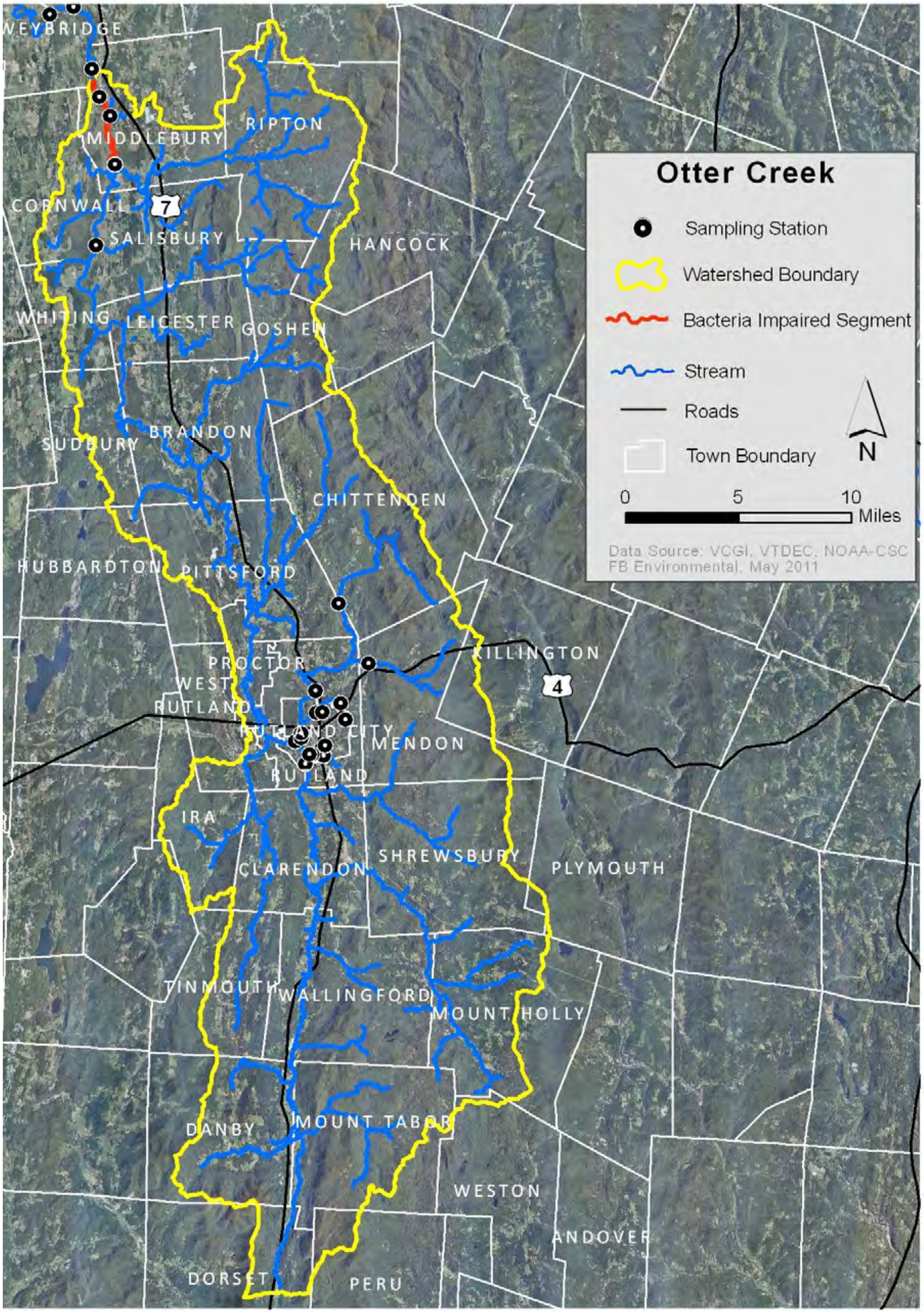

Figure 1: ***Map of Otter Creek watershed with impaired segment and sampling stations indicated.***

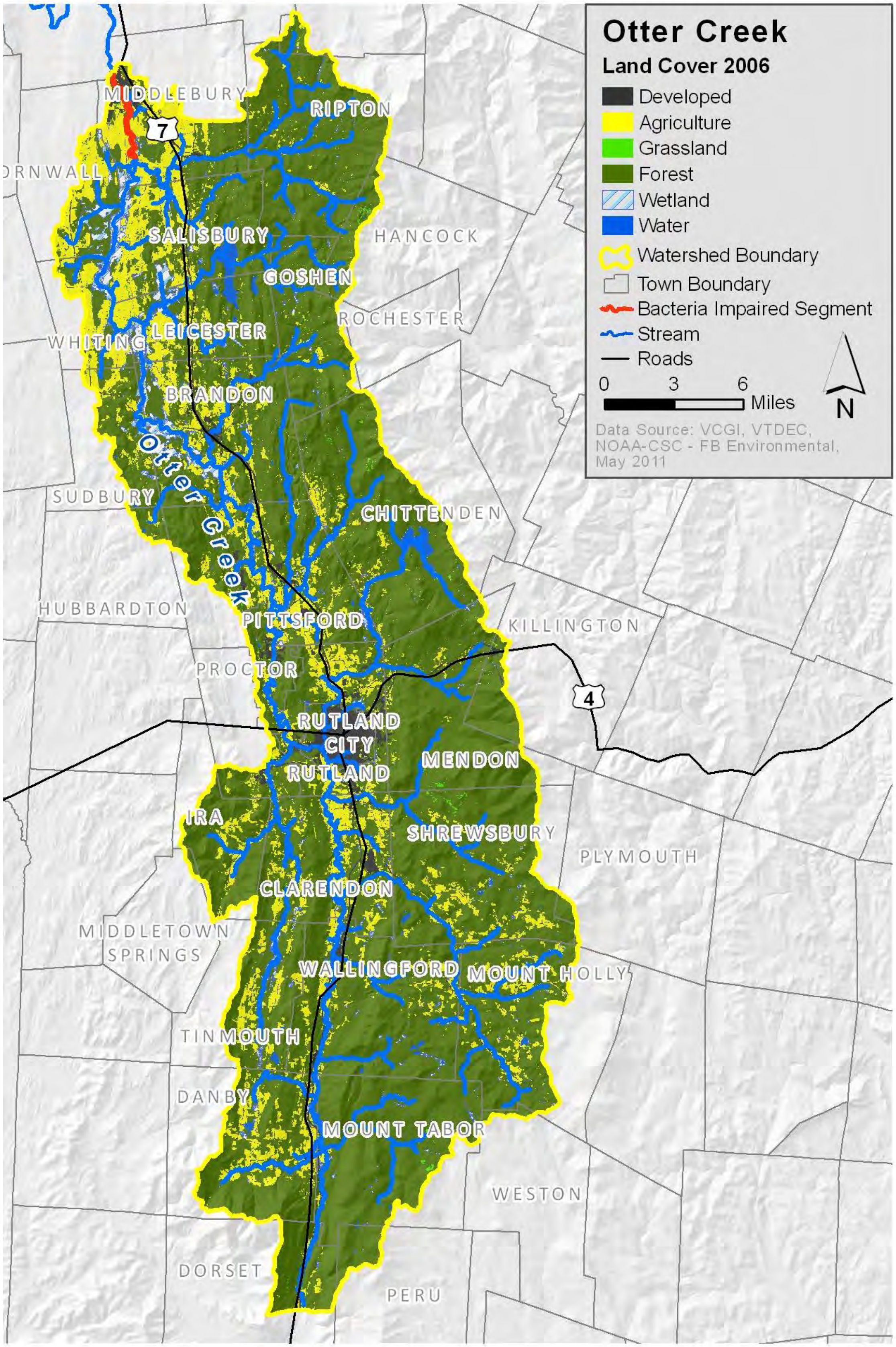

Figure 2: ***Map of Otter Creek watershed with impaired segment and land cover indicated.***

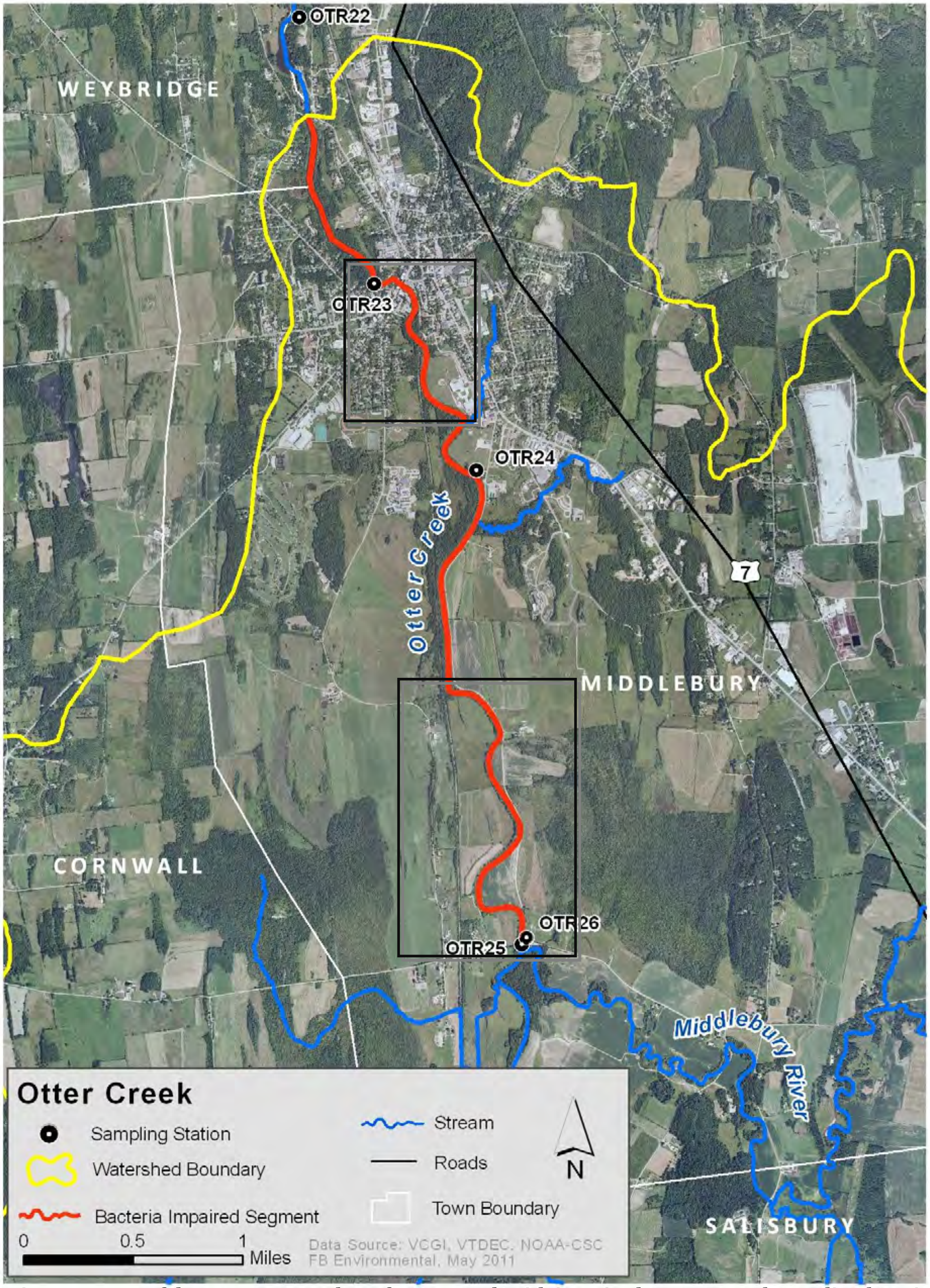

Figure 3: ***Map of downstream reaches of Otter Creek with impaired segment and sampling locations indicated. Inset areas correspond to Figures 4 and 5 below.***

Figure 4 shows the upstream start of the impaired segment at the confluence of Otter Creek and the Middlebury River. As seen in this aerial image, there are large tracts of agricultural land along the creek's banks. In the creek's entire watershed there are a total of 710 farms (NRCS, 2005). Around 200 of these are dairy farms, in addition to numerous beef, sheep, poultry, and vegetable farms. The entire watershed contains 122,000 acres of cropland and 41,000 acres of pasture (NRCS, 2005). Agriculture remains an important cultural and economic resource in Rutland and Addison County (RRPC, 2008). Much of the agricultural land surrounding the impaired segment, and in the creek's course through Addison County in general, was once wetland. Up to one-third of Addison County's farmland may have once been wetland (ACRPC, 1994).

Figure 4: ***Aerial view of Otter Creek from the upstream end of the impaired segment at the confluence with the Middlebury River (lower right). Stations OTR25 and OTR26 shown in Red***

From the beginning of the impaired segment at the confluence of the Middlebury River and Otter Creek, until the segments terminus, Otter Creek flows through two distinct land use types: large scale agriculture in the upper reaches and heavy development in downtown Middlebury in the downstream reaches. The upstream reach consists of agricultural land use which typically has narrow riparian buffers. The downstream reach consists of residential and commercial development. Both types of land use can potentially contribute bacteria to the creek. The types of land use, development and activities in a watershed affects water's movement, storage and ultimately its water quality (RRPC, 2008). The long term health of Otter Creek is closely linked to the use of best management practices (BMPs) on agricultural lands and in developed areas, aimed at reducing pollutant loads to the creek. Figure 5 provides an aerial view of a reach of Otter Creek as it passes through downtown Middlebury. In this downstream reach, Otter Creek is flanked by residential, municipal, and commercial development on both sides. Otter Creek's impaired segment ends under Pulp Mill bridge, but the creek continues flowing northward eventually emptying into Lake Champlain.

Why is a TMDL needed?

Otter Creek is a Class B, cold water fishery with designated uses including swimming, fishing and boating (VTDEC, 2008). The Addison County River Water Collaborative has been collecting samples from Otter Creek for analysis of *E.coli* since 1992 (ACRWC, 2009). Each summer, samples are collected from the sampling stations shown in Figure 3 (as well as many others not on the impaired segment). Bacteria data from downstream sampling locations OTR26, OTR24, and OTR23 have consistently exceeded Vermont's water quality criteria for *E.coli* bacteria. Table 1 below provides bacteria data collected in these downstream sampling locations from 2000 to 2007. Table 1 provides the water quality criteria for *E.coli* bacteria along with the individual sampling event bacteria results and geometric mean concentration statistics for each sampling season.

Due to the elevated bacteria measurements presented in Table 1, Otter Creek from the Pulp Mill Bridge upstream for 4.8 miles to the confluence with the Middlebury River, did not meet Vermont's water quality standards, was identified as impaired and was placed on the 303(d) list (VTDEC, 2008). The 303(d) listing states that use of Otter Creek for contact recreation (i.e., swimming) is impaired. The Clean Water Act requires that all 303(d) listed waters undergo a TMDL assessment that describes the impairments and identifies the measures needed to restore water quality. The goal is for all waterbodies is to comply with state water quality standards.

Potential Bacteria Sources

Given the location of the impaired segment as well as the makeup of the greater impaired segment watershed, sanitary sewer leaks, stormwater from developed areas, failing septic systems, and agricultural runoff are all possible causes of bacteria related surface water quality problems in Otter Creek.

The town of Middlebury is serviced by a municipal sewer system. This sewer system provides services to the downtown area and a portion of Route 7 (ACRCP, 2008). Therefore, the developments surrounding the lower reaches of the impaired segment are serviced by sanitary sewer. If there were to be any leaks within this sewer near Otter Creek, the waste from the sewer could enter the creek. Spills and leaks from sanitary sewer systems can pose threats to human health from high bacteria levels, and can cause ecological damage (Mallin et. al., 2007). One way of determining if there is a leak in a sanitary sewer is to test for optical brighteners. These chemicals are added to laundry detergents to make whither whites and brighter colors. Optical brighteners give off fluorescence in their excited state when light from specific ranges of the spectrum are shined on them. Water from washing machines is carried from homes and businesses in the sanitary sewer. If leaking sanitary sewers are suspected, the presence of optical brighteners from laundry detergent is one indication that leaks are present (Tavares et. al., 2009).

While the downtown area of Middlebury is serviced by sewer, most of the residents within the impaired segment watershed, as well as in Addison County, are not serviced by waste water treatment facilities and therefore rely on on-site septic systems to treat waste. Only 22% of residents within Addison County are serviced by waste water treatment facilities (ACRPC, 2008). Much of the watershed consists of heavy clay soils that make septic disposal difficult. The combination of relatively old septic systems and a relatively high water table with clay soils increases the probability of septic systems failing (ACRPC, 2008). When these systems malfunction or fail, they can release untreated human waste into surface waters, such as Otter Creek.

Stormwater flows off impervious surfaces such as driveways, rooftops, and roads when it rains. On these surfaces the water collects a suite of pollutants, including bacteria. The increased bacteria readings found within Otter Creek are water-related problems characteristic of urbanizing and urbanized areas. There is a multitude of possible sources for bacteria in stormwater. *E. coli* is a bacteria naturally found within the intestinal tract and thus fecal matter of warm blooded animals such as dogs, cows, birds, and humans. Its presence within surface water is a strong indication of fecal matter contamination. Testing for *E. coli* helps to indicate the presence of other water borne fecal pathogens that can pose serious threats to human health (USDA, 2000). One of the most widely documented and likely source of *E. coli* in stormwater from urban areas is pet fecal matter, specifically that of dogs. If residents are not properly disposing of their pet's fecal matter or not picking fecal matter up from streets where storm drains catch runoff, it can enter and contaminate Otter Creek.

Given the high proportion of agriculture uses within the watershed, the proximity of these activities to the creek, and the general lack of riparian buffers along the creek, agricultural activities are a likely source of bacterial contamination. The major water resource concerns associated with agriculture within the watershed are animal waste storage, nutrient management, pasture management, and riparian area management. When these aspects of farming are not managed properly harmful bacteria can enter the water (NRCS, 2005). Also, manure applications to croplands adjacent to the creek may result in fecal bacteria contributions.

Long term on-site improvement and restoration projects are being undertaken to help reduce agriculture runoff to Otter Creek (VTDEC, 2010). The Natural Resources Conservation Service, USEPA, and other agencies provided technical assistance and partial funding to support these projects (NRCS, 2005). These improvements include actions such as extending riparian buffers, reducing manure applications to areas adjacent to the creek, and storing animal waste away from the creek and its tributaries. Working with farmers and landowners to establish larger riparian buffers is the single most effective and likely the cheapest action an individual farmer, organization, or municipality can take to improve and protect surface water quality (RRPC, 2008).

Recommended Next Steps

The Addison County River Watch Collaborative (ACRWC) is working with VT DEC on developing and implementing an education and outreach program for several rivers including Otter Creek. ACRWC is also developing a comprehensive assessment for the waters they monitor which includes the bacteria impaired segment of Otter Creek. This is being done with funds from a Clean and Clear Watershed Planning Assistance grant (VTDEC, 2010). In addition, the Otter Creek River Front Committee and the Middlebury Stormwater Mitigation Project are working on a variety of BMPs that will help to decrease sedimentation, nutrient enrichment, and pathogenic bacteria to Otter Creek. This is especially important for Otter Creek's impaired segment as it flows through downtown Middlebury. Current and planned restoration activities include buffer planting, stream bank restoration, removal of agricultural land from production within the riparian corridor, and land conservation (VTDEC, 2010).

ACRWC, municipalities surrounding the impaired segment, and other community and watershed based groups are encouraged to continue implementing education and outreach programs, restoration programs, and the identification of land use activities that might be influencing *E. coli* levels (ACRWC, 2005). The data in Table 1 show that *E.coli* readings at station OTR23 are consistently higher than readings at the other two stations along the impaired segment of Otter Creek. At station OTR24, just as the impaired segment enters downtown Middlebury, 7% of the samples (2 out of 31) measured above the proposed single sample threshold (235 organisms / 100mL). At station OTR23, one mile downstream along the impaired segment, 47% of the samples (17 out of 36) measured above the proposed single sample threshold. This suggests that bacteria are entering Otter Creek between these two sampling locations in sufficient quantity to influence the readings at station OTR23. An aerial analysis of the reach above station OTR23 reveals extensive development surrounding the creek. There is a mix of residential and commercial properties adjacent to the creek. For nearly the entire mile between OTR23 and OTR24 the riparian zone is narrow or nonexistent. There is also a small tributary stream that enters the creek between the two sampling locations.

It is recommended that ACRWC implement additional data collection along the impaired segment's reach. It would be beneficial for source identification to sample water from the tributary stream before it enters Otter Creek. It would also be beneficial for the town of Middlebury to map out its storm drainage network to better understand where stormwater from the downtown area is entering Otter Creek. Better understanding of the storm drain network could help the town of Middlebury and ACRWC identify areas to place stormwater BMPs that would have the greatest impact on water quality. More sampling points, and analysis of the water that is entering the creek along its impaired reach will allow ACRWC to target education and outreach efforts to locations that are most likely to be contributing to the bacterial contamination.

Landowners along the impaired reach where agriculture is prevalent should be notified or reminded that organizations such as NRCS, USGS, the VT Department of Agriculture, and the Otter Creek Conservation District which provide assistance with the installation of BMPs helping to reduce bacteria, nutrients, and suspended sediment loads. Another recommendation is for ACRWC to sample at the different stations on the exact same day. This would allow samples to be collected during a time period when flows within the creek are consistent amongst the stations. Sampling upstream and downstream of potential sewer leaks, onsite septic, stormwater, and agricultural sources (a practice known as "bracket sampling") may also be beneficial for identifying and quantifying sources. Sampling activities focused on capturing bacteria data under different weather conditions (e.g., wet and dry) may also be beneficial in support of source identification. Field reconnaissance surveys focused on stream buffers, stormwater runoff, and other source identification may also be beneficial. These efforts should begin along the creek itself and move up through the tributaries and drainage networks, helping to pinpoint a potential water source at the creek and follow it up to where the bacteria may be entering that water source.

Previous plans and investigations in the area (RRPC, 2008; ACRPC, 1994; VTDEC, 2010) have recommended the following actions to support water quality goals in Otter Creek:

- On-Site Sewage System Management – Conduct a sanitary survey of domestic wastewater, work with Vermont environmental enforcement officers and local health officials to identify and replace failing systems. Conduct a review and potentially modify existing on-site sewage ordinances.
- Stormwater from developed areas – Provide a financial incentive for businesses and / or landowners that would like to implement stormwater BMPs on their property. Search for more sustainable funding for and support stormwater management projects. Incorporate education about the damaging effects of pet waste on water quality to try and influence residents to pick up after their pet.
- Agricultural - Work with the USDA, NRCS and other agencies to assess the extent of agricultural waste application and potentially reduce applications through improved nutrient management planning. Evaluate riparian buffer and identify opportunities to remove areas near the river from production.
- Land Use Protection - Preserve undeveloped portions of the watershed and institute controls on development near Otter Creek. Encourage communities to develop plans and regulations that

afford greater protection of wetlands that do not appear on the "Vermont Significant Wetlands Inventory."

- Riparian Corridor – Encourage communities to install regulations addressing setbacks, buffers, and other tools that protect shoreline and/or riparian areas. Continue riparian corridor projects and seek to enhance buffers through a combination of buffer plantings, land conservation, and improved agricultural practices.

Several of the steps outlined above are ongoing and should be continued and enhanced to focus on the goals of bacteria TMDL implementation. If implemented, these actions will provide a strong basis toward the goal of mitigating bacteria sources and meeting water quality standards in Otter Creek.

Bacteria Data

Vermont's current criteria for bacteria are more conservative than those recommended by EPA. For Class B waters, VTDEC currently utilizes an E. coli single sample criterion of 77 organisms/100ml. Although, Vermont is in the process of revising their bacteria WQS to better align with the National Recommended Water Quality Criteria (NRWQC) of a geometric mean of 126 organisms/100ml, and a single sample of 235 organisms/100ml. Therefore, in Table 1 below, bacteria data were compared to both the current VTWQS and the NRWQC for informational purposes.

Otter Creek, mouth of Middlebury River to Swamp Road Bridge (4.0 miles)

***WB ID*:** VT03-01

Characteristics: Class B

Impairment: *E. coli* (organisms/100mL)

Current Water Quality Criteria for E. coli:

Single sample: 77 organisms/100 mL

NRWQC for E. coli:

Single sample: 235 organisms/100 mL

Geometric mean: 126 organisms/100 mL

Percent Reduction to meet TMDL (Current):

Single Sample: **97%**

Percent Reduction to meet NRWQC:

Single sample: **90%**

Geometric mean: **47%**

Data: 2000 – 2007, Addison County River Watch Collaborative

Table 1: *E.coli* (organisms/100 mL) Data for Otter Creek (2000-2007) and Geometric Mean (organisms/100mL) for each Station based on Calendar Year.

Station Name	Station Location	Date	Result	Geometric Mean
OTR30	Salisbury Covered Bridge	8/22/2007	52	133
OTR30	Salisbury Covered Bridge	8/8/2007	79	
OTR30	Salisbury Covered Bridge	7/25/2007	53	
OTR30	Salisbury Covered Bridge	7/11/2007	345	
OTR30	Salisbury Covered Bridge	6/27/2007	548	
OTR30	Salisbury Covered Bridge	8/23/2006	219	80
OTR30	Salisbury Covered Bridge	8/2/2006	68	
OTR30	Salisbury Covered Bridge	7/19/2006	50	
OTR30	Salisbury Covered Bridge	7/5/2006	45	
OTR30	Salisbury Covered Bridge	6/21/2006	96	
OTR30	Salisbury Covered Bridge	8/17/2005	37	59
OTR30	Salisbury Covered Bridge	8/3/2005	42	
OTR30	Salisbury Covered Bridge	7/20/2005	56	
OTR30	Salisbury Covered Bridge	7/6/2005	95	
OTR30	Salisbury Covered Bridge	6/22/2005	90	
OTR30	Salisbury Covered Bridge	8/18/2004	326	104
OTR30	Salisbury Covered Bridge	8/4/2004	130	
OTR30	Salisbury Covered Bridge	7/21/2004	81	
OTR30	Salisbury Covered Bridge	7/7/2004	81	
OTR30	Salisbury Covered Bridge	6/23/2004	43	

*Shaded cells indicate single sample and geometric mean used to calculate percent reduction.
**Only geometric mean values calculated with 5 data points or more are used to determine percent reduction.

Table 1: *E.coli* (organisms/100 mL) Data for Otter Creek (2000-2007) and Geometric Mean (organisms/100mL) for each Station based on Calendar Year (continued).

Station Name	Station Location	Date	Result	Geometric Mean
OTR30	Salisbury Covered Bridge	8/6/2003	579	66
OTR30	Salisbury Covered Bridge	7/23/2003	81	
OTR30	Salisbury Covered Bridge	7/9/2003	16	
OTR30	Salisbury Covered Bridge	6/25/2003	25	
OTR30	Salisbury Covered Bridge	8/7/2002	41	36
OTR30	Salisbury Covered Bridge	7/27/2002	40	
OTR30	Salisbury Covered Bridge	7/10/2002	38	
OTR30	Salisbury Covered Bridge	6/29/2002	27	
OTR30	Salisbury Covered Bridge	8/11/2001	96	83
OTR30	Salisbury Covered Bridge	7/25/2001	43	
OTR30	Salisbury Covered Bridge	7/14/2001	148	
OTR30	Salisbury Covered Bridge	6/27/2001	78	
OTR30	Salisbury Covered Bridge	8/12/2000	54	52
OTR30	Salisbury Covered Bridge	7/26/2000	50	
OTR30	Salisbury Covered Bridge	7/15/2000	50	
OTR30	Salisbury Covered Bridge	6/28/2000	56	
OTR26	Three-mile Bridge	8/18/2004	93	122
OTR26	Three-mile Bridge	8/4/2004	75	
OTR26	Three-mile Bridge	7/21/2004	201	
OTR26	Three-mile Bridge	7/7/2004	111	
OTR26	Three-mile Bridge	6/23/2004	172	
OTR26	Three-mile Bridge	8/6/2003	2420	292
OTR26	Three-mile Bridge	7/23/2003	137	
OTR26	Three-mile Bridge	7/9/2003	91	
OTR26	Three-mile Bridge	6/25/2003	240	
OTR26	Three-mile Bridge	8/7/2002	44	138
OTR26	Three-mile Bridge	7/27/2002	236	
OTR26	Three-mile Bridge	7/10/2002	154	
OTR26	Three-mile Bridge	6/29/2002	228	
OTR26	Three-mile Bridge	8/11/2001	166	344
OTR26	Three-mile Bridge	7/25/2001	649	
OTR26	Three-mile Bridge	7/14/2001	238	
OTR26	Three-mile Bridge	6/27/2001	548	
OTR26	Three-mile Bridge	8/12/2000	2420	315
OTR26	Three-mile Bridge	7/26/2000	101	
OTR26	Three-mile Bridge	7/15/2000	201	
OTR26	Three-mile Bridge	6/28/2000	201	

*Shaded cells indicate single sample and geometric mean used to calculate percent reduction.
**Only geometric mean values calculated with 5 data points or more are used to determine percent reduction.

Table 1: *E.coli* (organisms/100 mL) Data for Otter Creek (2000-2007) and Geometric Mean (organisms/100mL) for each Station based on Calendar Year (continued).

Station Name	Station Location	Date	Result	Geometric Mean
OTR25	Downstream of mouth of Middlebury River	8/17/2005	80	63
OTR25	Downstream of mouth of Middlebury River	8/3/2005	54	
OTR25	Downstream of mouth of Middlebury River	7/20/2005	65	
OTR25	Downstream of mouth of Middlebury River	7/6/2005	52	
OTR25	Downstream of mouth of Middlebury River	6/22/2005	67	
OTR24	Midd. Union High School	8/17/2005	48	47
OTR24	Midd. Union High School	8/17/2005	19	
OTR24	Midd. Union High School	8/3/2005	31	
OTR24	Midd. Union High School	8/3/2005	31	
OTR24	Midd. Union High School	7/20/2005	44	
OTR24	Midd. Union High School	7/20/2005	44	
OTR24	Midd. Union High School	7/6/2005	58	
OTR24	Midd. Union High School	7/6/2005	67	
OTR24	Midd. Union High School	6/22/2005	83	
OTR24	Midd. Union High School	6/22/2005	90	
OTR24	Midd. Union High School	8/18/2004	74	102
OTR24	Midd. Union High School	8/4/2004	88	
OTR24	Midd. Union High School	7/21/2004	70	
OTR24	Midd. Union High School	7/7/2004	228	
OTR24	Midd. Union High School	6/23/2004	105	
OTR24	Midd. Union High School	8/6/2003	704	180
OTR24	Midd. Union High School	7/23/2003	130	
OTR24	Midd. Union High School	7/9/2003	286	
OTR24	Midd. Union High School	6/25/2003	40	
OTR24	Midd. Union High School	8/7/2002	31	79
OTR24	Midd. Union High School	7/27/2002	47	
OTR24	Midd. Union High School	7/10/2002	117	
OTR24	Midd. Union High School	6/29/2002	228	
OTR24	Midd. Union High School	8/11/2001	105	74
OTR24	Midd. Union High School	7/25/2001	65	
OTR24	Midd. Union High School	7/14/2001	71	
OTR24	Midd. Union High School	6/27/2001	61	
OTR24	Midd. Union High School	8/12/2000	165	55
OTR24	Midd. Union High School	7/26/2000	22	
OTR24	Midd. Union High School	7/15/2000	43	
OTR24	Midd. Union High School	6/28/2000	59	

*Shaded cells indicate single sample and geometric mean used to calculate percent reduction.
**Only geometric mean values calculated with 5 data points or more are used to determine percent reduction.

Table 1: ***E.coli*** **(organisms/100 mL) Data for Otter Creek (2000-2007) and Geometric Mean (organisms/100mL) for each Station based on Calendar Year (continued).**

Station Name	Station Location	Date	Result	Geometric Mean
OTR23	Frog-Hollow (below footbridge)	8/22/2007	38	90
OTR23	Frog-Hollow (below footbridge)	8/8/2007	121	
OTR23	Frog-Hollow (below footbridge)	7/25/2007	77	
OTR23	Frog-Hollow (below footbridge)	7/11/2007	210	
OTR23	Frog-Hollow (below footbridge)	6/27/2007	81	
OTR23	Frog-Hollow (below footbridge)	8/23/2006	308	133
OTR23	Frog-Hollow (below footbridge)	8/2/2006	387	
OTR23	Frog-Hollow (below footbridge)	7/19/2006	62	
OTR23	Frog-Hollow (below footbridge)	7/5/2006	38	
OTR23	Frog-Hollow (below footbridge)	6/21/2006	147	
OTR23	Frog-Hollow (below footbridge)	8/17/2005	326	163
OTR23	Frog-Hollow (below footbridge)	8/3/2005	93	
OTR23	Frog-Hollow (below footbridge)	7/20/2005	345	
OTR23	Frog-Hollow (below footbridge)	7/6/2005	179	
OTR23	Frog-Hollow (below footbridge)	6/22/2005	62	
OTR23	Frog-Hollow (below footbridge)	8/18/2004	91	236
OTR23	Frog-Hollow (below footbridge)	8/4/2004	112	
OTR23	Frog-Hollow (below footbridge)	7/21/2004	178	
OTR23	Frog-Hollow (below footbridge)	7/7/2004	1046	
OTR23	Frog-Hollow (below footbridge)	6/23/2004	387	
OTR23	Frog-Hollow (below footbridge)	8/6/2003	816	682
OTR23	Frog-Hollow (below footbridge)	7/23/2003	461	
OTR23	Frog-Hollow (below footbridge)	7/9/2003	1050	
OTR23	Frog-Hollow (below footbridge)	6/25/2003	548	
OTR23	Frog-Hollow (below footbridge)	8/7/2002	182	297
OTR23	Frog-Hollow (below footbridge)	7/27/2002	579	
OTR23	Frog-Hollow (below footbridge)	7/10/2002	196	
OTR23	Frog-Hollow (below footbridge)	6/29/2002	378	
OTR23	Frog-Hollow (below footbridge)	8/11/2001	326	272
OTR23	Frog-Hollow (below footbridge)	7/25/2001	285	
OTR23	Frog-Hollow (below footbridge)	7/14/2001	238	
OTR23	Frog-Hollow (below footbridge)	6/27/2001	248	
OTR23	Frog-Hollow (below footbridge)	8/12/2000	411	152
OTR23	Frog-Hollow (below footbridge)	7/26/2000	65	
OTR23	Frog-Hollow (below footbridge)	7/15/2000	122	
OTR23	Frog-Hollow (below footbridge)	6/28/2000	165	

*Shaded cells indicate single sample and geometric mean used to calculate percent reduction.
**Only geometric mean values calculated with 5 data points or more are used to determine percent reduction.

Table 1: *E.coli* (organisms/100 mL) Data for Otter Creek (2000-2007) and Geometric Mean (organisms/100mL) for each Station based on Calendar Year (continued).

Station Name	Station Location	Date	Result	Geometric Mean
OTR22	Below Pulp Mill Bridge	8/17/2005	25	54
OTR22	Below Pulp Mill Bridge	8/3/2005	36	
OTR22	Below Pulp Mill Bridge	7/20/2005	55	
OTR22	Below Pulp Mill Bridge	7/6/2005	83	
OTR22	Below Pulp Mill Bridge	6/22/2005	114	
OTR22	Below Pulp Mill Bridge	8/18/2004	105	176
OTR22	Below Pulp Mill Bridge	8/4/2004	99	
OTR22	Below Pulp Mill Bridge	7/21/2004	86	
OTR22	Below Pulp Mill Bridge	7/7/2004	204	
OTR22	Below Pulp Mill Bridge	6/23/2004	921	
OTR22	Below Pulp Mill Bridge	8/6/2003	345	164
OTR22	Below Pulp Mill Bridge	7/23/2003	345	
OTR22	Below Pulp Mill Bridge	7/9/2003	101	
OTR22	Below Pulp Mill Bridge	6/25/2003	60	
OTR22	Below Pulp Mill Bridge	8/7/2002	116	131
OTR22	Below Pulp Mill Bridge	7/27/2002	82	
OTR22	Below Pulp Mill Bridge	7/10/2002	194	
OTR22	Below Pulp Mill Bridge	6/29/2002	161	
OTR22	Below Pulp Mill Bridge	8/11/2001	116	135
OTR22	Below Pulp Mill Bridge	7/25/2001	162	
OTR22	Below Pulp Mill Bridge	7/14/2001	160	
OTR22	Below Pulp Mill Bridge	6/27/2001	109	
OTR22	Below Pulp Mill Bridge	8/12/2000	201	96
OTR22	Below Pulp Mill Bridge	7/26/2000	59	
OTR22	Below Pulp Mill Bridge	7/15/2000	70	
OTR22	Below Pulp Mill Bridge	6/28/2000	101	

*Shaded cells indicate single sample and geometric mean used to calculate percent reduction.
**Only geometric mean values calculated with 5 data points or more are used to determine percent reduction.

References

ACRPC (1994). Addison County Regional Planning Commission, Addison County Regional Plan: Section 4: Natural Resources. Last updated April 13, 1994 (website) www.acrpc.org/pages/publications/Reg_Plan/NR_TOC.htm, accessed online on February 10, 2011

ACRPC (2008). Addison County Regional Planning Commission, Addison County Regional Plan: Section 7: Utilities, Facilities and Services. Last updated May 14, 2008

ACRWC (2005). Addison County River Watch Collaborative. 2005 Stream-Monitoring Report. Otter Creek and Middlebury River

ACRWC (2009). 2009 Watershed Outreach Brochure: Otter Creek. Addison County River Watch Collaborative

ACRWC (2011). Summary Report: 2010 Sampling Results, Addison County River Watch Collaborative, February 25, 2011. Prepared for: Jim Kellogg, VTDEC Water Quality Division. Prepared by: Kristen Underwood, South Mountain Research & Consulting and ACRWC.

Mallin, et. al. (2007). Mallin, M.A., L.B. Cahoon, B.R. Toothman, D.C. Parsons, M.R. McIver, M.L. Ortwine and R.N. Harrington. 2007. Impacts of a raw sewage spill on water and sediment quality in an urban estuary. Mar. Pollution Bull. 54:81-88

Nature (Undated). The Nature Conservancy, Otter Creek Swamps: Cornwall, Whiting and Brandon Vermont. (Website) www.nature.org/wherewework/northamerica/states/vermont/preserves/art20199.html, accessed online on February 10, 2011

NRCS (2005). 2005 Conservation Security Program. West River and Otter Creek Watersheds. Natural Resources Conservation Service, U.S. Department of Agriculture (website) www.vt.nrcs.usda.gov/programs/CSP/CSP_2005/Index.html, accessed online on February 10, 2011

RRPC (2008). Rutland Regional Planning Commission, Rutland Regional Plan; Chapter 14: Water Quality. Plan Adopted in 2008. Available online at: www.rutlandrpc.org/Plan08/14_Water_Quality.pdf, accessed online on February 10, 2011

Tavares et. al. (2009). Tavares, M.D., M.I.H. Spivey, M.R. McIver and M.A. Mallin. 2008. Testing for Optical Brighteners and Fecal Bacteria to Detect Sewage Leaks in Tidal Creeks. University of North Carolina Wilmington, Center for Marine Sciences. Available online at: http://people.uncw.edu/hillj/classes/EVS595/Optical%20brightener%20paper%20for%20NCAS.pdf, accessed online on February 7, 2011.

VTDEC (2010). Progress Report on River Basin Water Quality Management Planning During 2009. A Report for: House and Senate Committees on Agricultural and Natural Resources and Energy. Prepared by: Vermont Agency of Natural Resources, Department of Environmental Conservation, Water Quality Division, Waterbury, VT. January, 2010

VTDEC (2008). State of Vermont, 2008, 303(d) List of Waters, Part A – Impaired Surface Waters in Need of TMDL, October 2008 (Approved by USEPA September 24, 2008). Prepared by: Vermont Department of Environmental Conservation, Water Quality Division, Waterbury, VT.

VTF&W (undated). Cornwall Swamp Wildlife Management Area. Vermont Fish & Wildlife Department Available online at: www.vtfishandwildlife.com/library/maps/Wildlife Management Areas/Essex District/Cornwall Swamp WMA.pdf, accessed online on February 10, 2011